EXPERIMENTAL INVESTIGATION ON STRENGTH OF CONCRETE USING BASALT FIBRE

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***Abstract**: This paper deals with the effect of basalt fibre, a high performance metallic fiber when mixed with concrete. Concrete is the widely used construction material, but it is known that concrete is weak in tension and is easily liable to cracking, which further leads to cracks in buildings thereby reducing the strength of the structure. The present study focuses on investigation on strength of concrete using different dosages and diameters of basalt fibres. The concrete reinforced with basalt fibre was cast on different specimens like cube, cylinder, prism and beam. Tests were conducted on the specimens for determining the compressive, split tensile and flexural strength of concrete. The strength of concrete had improved which depends on the amount of basalt fibre added to it.*

Keywords: Basalt fibre concrete(BFC), compressive strength, split tensile strength, flexural strength.

1.INTRODUCTION

Concrete is the most extensively used material in the construction field for the past few decades. Concrete is a mixture of cement paste, coarse and fine aggregates and water at the desired ratio. Though, it is the most widely used composite material, it is known that, it is strong in compression and weak in tension. Due to the low tensile strength, damage occurs to the structure, which requires better construction methods.

A lot of research works are being conducted all over the world to find out a cost effective, eco- friendly composite material. As a result, the use of natural fibres that gives better performance to artificial fibres are recommended in recent times. Generally, fibres are considered as crack arrestors, reducing the failure of the structure gradually. The use of fibre reinforced concrete is to impart additional energy absorbing capacity and for the transformation of material from brittle to ductile nature. Fibre reinforced concrete also increases toughness, resistance to plastic shrinkage and cracking of mortar. Examples of fibres used in the construction field includes steel, glass, synthetics, carbon, basalt fibres etc.,

2. BASALT FIBRE

Basalt fibre is a material made from extremely fine fibres of basalt, which is composed of the materials plagioclase, pyroxene and olivine. It is similar to fibre glass, having better physiomechanical properties than fibre glass, and cheaper than carbon fibre.

Basalt fibre is made from a single material, crushed basalt. The manufacture of basalt fibre requires the melting of the crushed and the washed basalt rock at 1500^{0}C(2730^{0}F). The molten rock is then extruded through small nozzles to produce continuous filaments of basalt fibre.

The properties of basalt fibre are shown in Table I.

Table-I: Properties of Basalt fibre

Properties	Value
Density	2.67 g / cm^3
Elastic Modulus	85-87 GPa
Specific gravity	2.8
Tensile strength	2000-2840 MPa
Elongation at break	3.15%

2.1 Why Basalt Fibre?

The fibres used in concrete control the plastic shrinkage and drying shrinkage cracking. There also few fibres that reduce the strength of concrete. The actual amount of fibres needed to add in the concrete mass depends on the characteristic test in laboratory. To attain good quality fibre reinforced concrete, the fibres must be distributed homogeneously throughout the cross-section area. Fibres such as naturally occurring and synthetic organic fibres with low modulus, when added to cement paste, do not impart greater strength compared to fibres with high modulus such as steel and glass.

Basalt fibre a naturally available fibre, does not possess any health hazards as in case of carbon fibres and does not create any pollution to the atmosphere. It imparts better strength to the concrete compared to the other available fibres. Since, basalt fibre is cost effective with sufficient availability and with high shear strength, it is suitable for the construction industry.

3. MATERIALS AND MIX PROPORTIONS

The materials used for the preparation of concrete mix are cement paste, coarse and fine aggregates, water, superplasticizers and water.

Mix design of M40 grade of concrete is designed using IS 10262:2009. A mix proportion of 1:2.52:3.25:0.4(cement:fine aggregates:coarse aggregates 20mm:water) for M40grade was calculated. Portland cement of grade 53 was used confirming to IS 12269:2013 ,water cement ratio of 0.4 was maintained for all mixes. Basalt fibre of dosages 0%, 0.1%, 0.2%, 0.3% by volume fraction of concrete.

Different dosages of basalt fibre is given in Table-II.

BFRC 1- 0.1 % Basalt Fibre Reinforced Concrete.

BFRC 2- 0.2 % Basalt Fibre Reinforced Concrete.

BFRC 3- 0.3 % Basalt Fibre Reinforced Concrete.

Table-II: BASALT FIBRE DOSAGE

Basalt fibre	Plain concrete	BFRC 1	BFRC 2	BFRC 3
% volume fraction of basalt fibre	0.00	0.1	0.2	0.3
Basalt fibre(kg/m^3)	0.00	0.35	0.7	1.05

4. EXPERIMENTAL SETUP

Cube of mould size 150mm x 150mm x 150mm, cylinders of mould size 100mm x 200mm and beam mould of size 100mm x 150mm were cast and cured.

5. TESTS ON CONCRETE

5.1 Basic Tests on Materials

Specific gravity test was done on fine and coarse aggregates using pycnometer. The fineness modulus was calculated using sieve analysis test.

The impact test was done to determine the toughness using impact testing machine ,abrasion test was done using Los Angels abrasion machine. The consistency of cement was found using Vicat's Apparatus. The results of these tests are tabulated in Table-III.

5.1 Tests on Fresh Concrete

The workability of fresh concrete is measured using the Vee Bee Consistometer apparatus. This test is used to measure the change in the concrete shape from slump cone to cylinder by mode of vibration.

5.2 Tests on Hardened Concrete

Compressive strength

Compressive strength tests were carried out on concrete cubes in Universal Testing Macne(UTM) of capacity 2000kN under 140kg/sq.cm/min loading rate, until the resistance of the specimen to the increasing load can be sustained. The results are shown in Table-IV. The compressive strength of concrete can be calculated using Equation (1).

$f_{cu} = P / A$ (N/mm^2) (1)

where,

f_{cu} = compressive strength of concrete (N/mm^2)

P = load applied (N)

A = cross sectional area (mm^2)

Flexural strength

The flexural strength or modulus of rupture of concrete was determined for the beams cast. The results are shown in Table-V. The flexural strength of concrete can be calculated using Equation (2).

$f_{cr} = PL / bd^2$ (N/mm^2) (2)

where,

f_{cr} = flexural strength of concrete (N/mm$^{2)}$

P = load applied (N)

L = effective span (mm)

b = breadth (mm)

d = depth (mm)

Split tensile strength

Cylindrical specimens were cast and cured to determine the split tensile strength of concrete. They were loaded in compression side along the diameter plane. The results of the split tensile strength are tabulated in Table-VI. the formula to calculate the split tensile strength is given in equation (3).

$f_t = 2P / \Pi DL$(N/mm^2) (3)

where,

f_t = split Stensile strength of concrete (N/mm^2)

P = load applied (N)

D = diameter (mm)

L = effective span (mm)

6. RESULTS AND DISCUSSION

- The Vee Bee times for plain concrete, BFRC 1, BFRC 2, BFRC 3 are 7s, 8s, 9.1s,12.5s.
- From the results it is seen that with increase in fibre content the workability reduces i.e., the vee bee time increases.
- The compressive strength of concrete increases with increase in basalt fibre content upto a certain level.
- The flexural and the split tensile strengths of concrete increases with increase in basalt fibre.

The results of the basic tests, compressive strength, flexural strength and split tensile strength are shown in Tables -III, IV,V,VI below.

Table-III: Basic tests on materials

S.NO	PROPERTIES	VALUE
1	Specific gravity of coarse aggregates	3.5
2	Specific gravity of fine aggregates	3.07
3	Fineness modulus	2.25
4	Impact value	14.9%
5	Abrasion value	34
6	Consistency of cement	30%

Table-IV: Compressive strength(N/mm^2)

Compressive strength(N/mm^2)		
	7 days	28 days
Plain concrete	25	40
BFRC 1	22	30
BFRC 2	27	30
BFRC 3	27.5	32

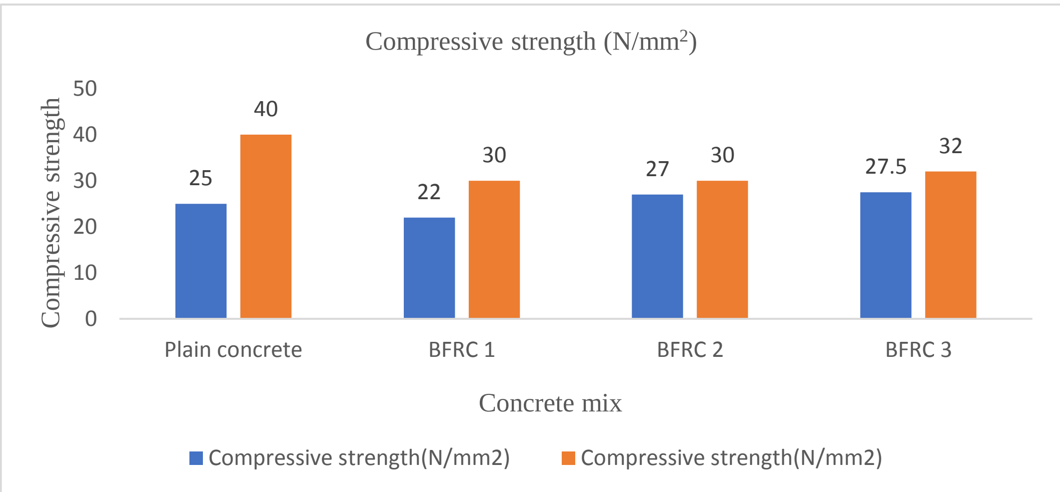

Chart-1: Compressive strength

Table-V: Flexural strength(N/mm²)

Flexural strength(N/mm²)		
	7 days	28 days
Plain concrete	1.3	2.1
BFRC 1	1.05	2.15
BFRC 2	1.2	2.15
BFRC 3	1.32	2.3

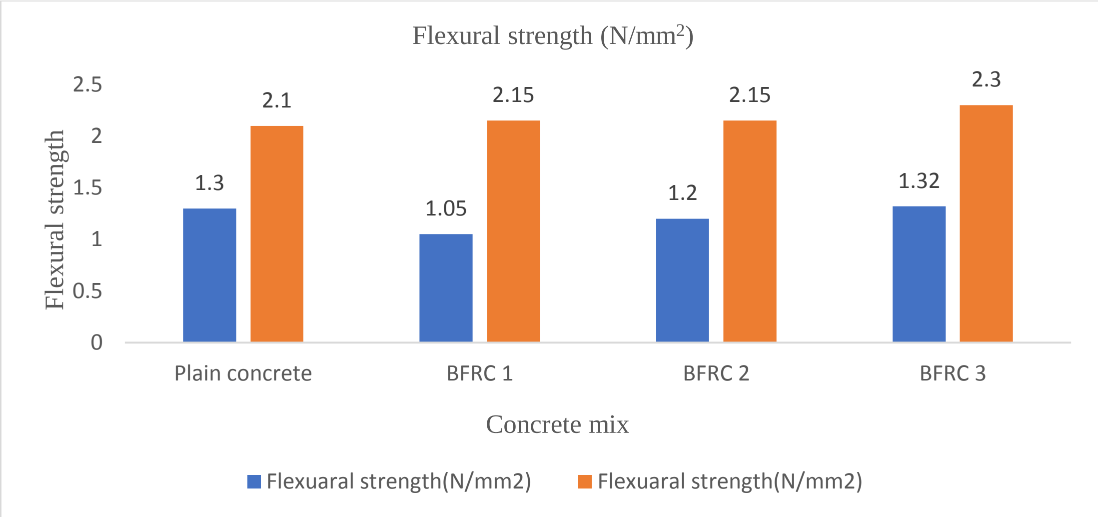

Chart-2: Flexural strength

Table-VI: Split tensile strength(N/mm²)

Split tensile strength(N/mm²)		
	7 days	28 days
Plain concrete	1.1	2.5
BFRC 1	1.56	2.2
BFRC 2	2.1	2.5
BFRC 3	1.95	2.7

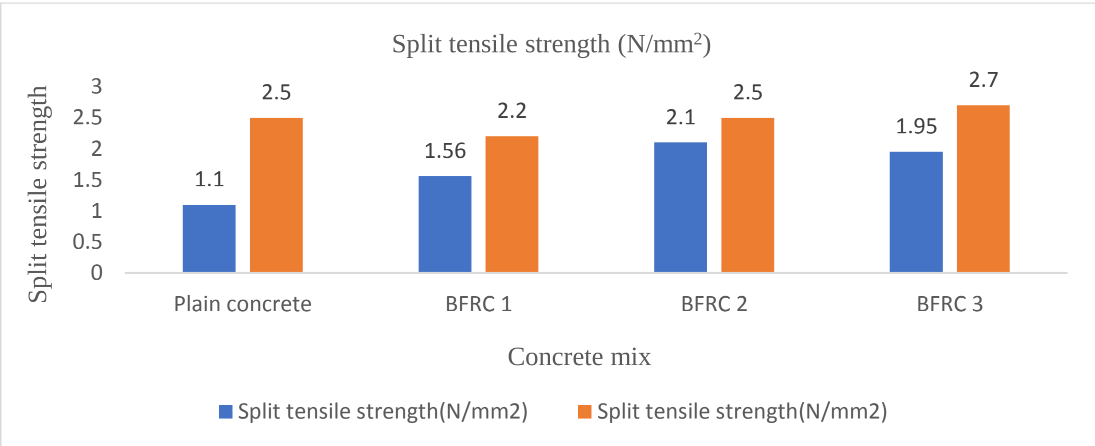

Chart-3 : Split tensile strength

7. CONCLUSIONS

1. When adding fibre to concrete the strength of concrete will decrease on 7 and 14 days.
2. It is studied that strength of basalt fibre will be more after 28 days curing.
3. Basalt fibres are non-acidic and have no toxic reaction with air or water.
4. Basalt fibres are added to overcome the defect that concrete is weak in tension.
5. The tensile and the flexural strengths will be more than the strengths of plain concrete.
6. There are chances for higher strengths when fibres of greater length and more dosage is added to the mix.

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